Nature Conservation

Nature Conservation 60: 1–19 (2025)
DOI: 10.3897/natureconservation.60.140566

Research Article

Mountain lions (*Puma concolor*) and their current management: Texas residents' knowledge and attitudes

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Abstract

Texas hosts approximately seven percent of the United States of America's mountain lion (*Puma concolor*) population, although this estimate might be high due to their non-game status and lack of regulation. In August 2022, the Texas Parks and Wildlife Department (TPWD) rejected a petition to change state mountain lion policy and established a stakeholder working group to evaluate potential management strategies. Here, we synthesised survey data collected from 740 Texas residents on their knowledge and attitudes about mountain lions and their regional management that is immediately relevant to the ongoing decisions being made by the Mountain Lion Working Group, the Texas Parks and Wildlife Commission, the state-wide mountain lion management plan working group and TPWD more generally. Overall, Texans correctly reported that mountain lions are rare in Texas, but misreported that they are protected. Generally, participants were positive about mountain lions and supported their management. Hunters and livestock producers expressed more positive attitudes for mountain lions and their management than did non-hunters and people who did not own livestock. In contrast to previous research on support for carnivore conservation, we did not detect any differences in responses between rural and urban residents. Together, these data suggest that the traditional constituents of TPWD (i.e. hunters and livestock owners) are supportive of policies that have been proposed for inclusion in a state management plan for the species, such as mandatory reporting of any mountain lion killed for any purpose. Our results highlight the importance of TPWD's prioritisation of public outreach and education targeting a greater diversity of Texans to: 1) mitigate the perceptions of risks and/or costs associated with mountain lions; 2) increase public knowledge about mountain lions and their management and 3) foster greater trust in natural resource governance to prevent disengagement by the public.

Key words: Attitudes, mountain lion, policy, *Puma concolor*, surveys, Texas Parks and Wildlife Department, Texas residents, wildlife management

OPEN ACCESS

Academic editor: Natasha Constant
Received: 29 October 2024
Accepted: 6 September 2025
Published: 7 October 2025

ZooBank: https://zoobank.org/0E42F550-B6F0-4A52-AF8E-22C25C36F3A8

Citation: Ohrens O, Ghasemi B, Gulas-Wroblewski BE, Elbroch LM (2025) Mountain lions (*Puma concolor*) and their current management: Texas residents' knowledge and attitudes. Nature Conservation 60: 1–19. https://doi.org/10.3897/natureconservation.60.140566

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Introduction

Conservation as a practice has primarily focused on mitigating human impacts on wildlife and ecosystems, rather than building co-existence through co-adaptation (Pooley et al. 2021; Carter and Linnell 2023). Ultimately, legislation, policy

and regulation are amongst the more powerful conservation tools because of the extent (i.e. the geographic range of jurisdictions) and longevity of their impact on human behaviour that impact wildlife populations (Musgrave and Stein 1993; Langhammer et al. 2024). Consequently, conservation practitioners attempt to understand what conservation issues people support and which they do not. Unlike behaviour, attitudes are difficult to observe. Instead, researchers generally rely upon strategic survey designs with the intention of linking survey data understood to be representative of specific human values and attitudes, to potential or current behaviour impacting conservation agendas (Pierce et al. 2001; Bennett et al. 2016). Here, we synthesise survey data on the attitudes of Texas residents towards mountain lions (*Puma concolor*) relevant to current management decisions about potential conservation policy for the species and the current development of a state-wide mountain lion management plan.

These data also provided us with the opportunity to test several hypotheses related to stakeholder attitudes and perceptions of wildlife management that have found support in previous research. Scientific evidence thus far suggests that hunters, livestock owners and rural residents experience greater tangible (e.g. livestock losses) and intangible (e.g. fear) "costs" of living with large carnivores, as well as more often face the real (e.g. actual damage) and perceived risks (e.g. vulnerability to damage) posed by mountain lions to livestock and ungulate hunting opportunities (Davenport et al. 2010; Young et al. 2015; Knopff et al. 2016; Elbroch et al. 2017; Mitchell et al. 2018). For these reasons, we hypothesised that hunters, livestock owners and people in rural counties would express less support for mountain lions and mountain lion conservation management than non-hunters, people without livestock and people who live in urban and suburban counties, as has been shown elsewhere (Davenport et al. 2010). Secondly, we tested the assumption that the majority of Texans are anti-trapping and, therefore, opposed to trapping-based management and the trapping of mountain lions, as previous research has suggested that most people do not support these measures, except in the defence of livelihoods (Vantassel et al. 2010; White et al. 2021).

Methods

Background

As of 2021, the Texas Parks and Wildlife Department (TPWD) lists mountain lions as S2/S3 on its Species of Greatest Conservation Need (TPWD 2021). S2 is an Imperilled classification defined as, "Imperilled in the nation or state/province because of rarity due to very restricted range, very few populations (often 20 or fewer), steep declines or other factors making it very vulnerable to extirpation from the nation or state/province" and S3 is a Vulnerable classification defined as "Vulnerable in the nation or state/province due to a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, other factors making it vulnerable to extirpation". Despite these trends, mountain lions in Texas continue to be classified as "non-game" and can be killed in any quantity, by any method and at any time of year. In addition, Texas residents are not required to report any mountain lion harvest or mortality to TPWD.

Chapter 67 of the Texas Parks and Wildlife Code (TPWD 2023) directs the TPWD to develop management programmes that ensure sustainable non-game wildlife populations (Section 67.002) and to conduct research of non-game to develop the necessary information on their populations in order to manage them (Section 67.003). Although mountain lions are listed as a Species of Greatest Conservation Need, the TPWD does not monitor or estimate their abundance. This lack of monitoring raises questions about whether current management practices fully align with the agency´s statutory responsibilities, including those outlined in Section 34 of the Texas Constitution, which emphasises sustainable use of wildlife resources for future generations (The Texas Constitution 2023). Further evaluation of management policies regarding mountain lion hunting may be warranted to ensure sustainability and compliance with relevant legal frameworks.

In June 2022, a stakeholder working group composed of Texas residents, scientists, advocates, a veterinarian and other private citizens (Texans for Mountain Lions 2022) submitted a Petition for Rulemaking to TPWD and the Texas Wildlife Commission requesting the following six changes to Texas wildlife policy as governed by TPWD: 1) Conduct a state-wide study to identify the abundance, status and distribution of the mountain lion populations in Texas; 2) Require mandatory reporting of wild mountain lions killed or euthanised for any reason by members of the public, state and federal agents acting in their official capacity and other wildlife responders; 3) Require trappers employing any form of trap or snare to capture mountain lions to examine their devices at least once every 36 hours, to make mountain lion trapping consistent with current fur-bearer trapping regulations in Texas; 4) Limit mountain lion take in south Texas to five animals per year until TPWD can determine the size and status of the population in this area and a stakeholder advisory group can establish sustainable hunting limits for the region; 5) Prohibit the take of mountain lions that have been restricted from movement during a hunt or prior to a hunt; 6) Form a stakeholder advisory group to collaborate with TPWD to write a mountain lion management plan for Texas (see Elbroch et al. (2024) for additional context).

In August 2022, TPWD denied this Petition, but provided a full presentation on the status of mountain lions in the State to the Texas Wildlife Commission. Consequently, the Commission mandated that TPWD fulfill the sixth request in the Petition and form a stakeholder group to assess the merits of the full Petition. In February 2023, TPWD hosted its first mountain lion stakeholder working group meeting, which included parties invited by the agency. Although the specific criteria for participant selection were not publicly detailed, invitees appeared to represent key constituent groups with interests in mountain lion management and related issues.

To provide information about the proceedings of subsequent meetings of this stakeholder working group, the most recent working group tasked with drafting Texas' first mountain lion management plan, the Texas Wildlife Commission and TPWD, we synthesised survey data to generate summaries of the attitudes of Texas residents about mountain lions and carnivore management practices, with the goal of predicting support for proposed policies (Pierce et al. 2001). The survey included questions intended to assess a respondent's knowledge about the current status of mountain lions in Texas, their attitudes about

and support for the species, scientific research, current mountain lion management and TPWD more generally. In addition, respondents were asked for input on best practices for trapping regulations for mountain lions and whether they approved of trapping or hunting as management tools for the species.

Survey instrument and sampling

We applied novel analyses to a subset of data that were collected as part of a longer survey (n = 137 questions total; Ghasemi et al. (2022)), which was subsequently shared in a technical report, but not in a peer-reviewed publication. The survey instrument was designed in Qualtrics software, both in English and Spanish and administered online by Qualtrics to fill specific quotas (Ghasemi et al. 2022). Qualtrics' online participant panels are recruited from various sources (e.g. targeted emails, website intercepts, social media) and panel members' names and addresses are validated prior to joining the panel. Panellists are then recruited to participate via email invitation, informing them that they will be compensated for their participation (the type and extent of compensation varies). Qualtrics does not disclose how many invitations were sent.

Participants from rural areas are generally less abundant than urban participants in online surveys (Smyth et al. 2010); nevertheless, the goal was to obtain equal samples or quotas with 50% of respondents drawn from urban/suburban zip codes and the other 50% drawn from rural zip codes, as defined in the United States Census Bureau (2016). Data collection was conducted from November 2021 through January 2022 and the survey instrument and procedure were approved by the Texas A&M University Institutional Review Board (No. 2021-1339M).

Participants were required to be at least 18 years of age. They were asked for initial demographic data, including their sex, residence and ethnicity. Participants were then asked whether they had participated in hunting or trapping of any wildlife in the last 12 months, which we used to define "hunters" versus "non-hunters". Participants were also asked whether they had participated in any livestock (i.e. cattle, dairy cows, goats and/or sheep) husbandry in the last 12 months, to define "livestock owners" as distinct from people who did not own or raise livestock.

Measurement

Knowledge of the Current Status of Mountain Lions in Texas

Participants were asked two questions about the current status of mountain lions in Texas. First, they were asked to characterise mountain lion populations as one of five options: 1) Extinct; 2) Endangered; 3) Rare, but not endangered; 4) Common; or 5) I don't know. Second, participants were asked to select the legal status of mountain lions from amongst four options: 1) Game animal with controlled seasons regulating when and how many can be hunted or trapped; 2) Non-game animal with no hunting or trapping restrictions; 3) Protected animal that cannot be legally hunted or trapped; or 4) I don't know.

General Attitudes about Mountain Lions, Mountain Lion Management and Research and the Texas Parks and Wildlife Department

Each participant received a unique combination of 10 randomly selected items regarding the three topics of mountain lions, mountain lion management and trust in TPWD, resulting in different sample sizes for each analysis. People responded to statements on these topics by choosing from amongst five options representing a 5-point Likert scale ranging from -2 to 2: 1) strongly disagree; 2) somewhat disagree; 3) neither agree nor disagree; 4) somewhat agree; or 5) strongly agree.

For the first topic, we combined the responses of five statements (Table 1) to quantify people's general attitudes about mountain lions (Cronbach's alpha = 0.75). We used the inverse values for statement 5 so as to combine results with a potential sum of -10 to 10. For the second topic, we combined participant responses to four statements (Table 1) to determine whether people in general are supportive of managing mountain lions (Cronbach's alpha = 0.72). We used the inverse values for statement 2 to combine the results of these four statements to create a potential sum of -8 to 8. For the third topic, we combined the responses for seven statements that reflect people's trust in TPWD's current actions related to mountain lions to create a potential sum of -14 to 14 (Table 1) (Cronbach's alpha = 0.90). We considered mean responses for these three topics to be unsupportive when their values were negative and their 95% confidence intervals (CIs) did not overlap with 0, neutral if CIs overlapped zero and to be supportive if their values were positive (Nakagawa and Cuthill 2007).

Following these analyses, we also calculated Potential for Conflict Index (PCI_2) scores (Vaske et al. 2010) to assess the relative consensus amongst participants with regard to their responses to individual statements in each of the three topics (see Table 1). PCI_2 values range from 0 to 1, where 0 indicates complete consensus and zero potential for conflict and 1 indicates complete disagreement and the highest potential for conflict.

Trapping Regulations and Mandatory Harvest Reporting

Participants were asked to select one of eight options related to how often trap regulations should require trappers to check their traps in the field or what they believe about trapping more generally: 1) Daily; 2) 36 hours; 3) 48 hours; 4) 72 hours; 5) Weekly; 6) There should not be trap checks regulations; 7) Unsure; or 8) Trapping should not be allowed. In addition, participants were asked whether they support mandatory harvest reporting for mountain lions with three possible responses: 1) yes; 2) no; or 3) unsure. Data were analysed as described below.

Other Management Considerations

We asked three additional questions that provide insight and guidance for decision-makers and policy-makers with regard to future mountain lion management. We enquired whether: 1) Trapping was an acceptable management practice for mountain lions; 2) Hunting was an acceptable management practice for mountain lions; and 3) Whether the participant would endorse a management plan inclusive of a compensation programme for livestock producers who lose

Table 1. Statements used in our analyses regarding general attitude about mountain lions, mountain lion management and trust in the state management of mountain lions.

Statements from which we derived a general attitude about mountain lions:
1. Seeing the track of a mountain lion would help me enjoy an outdoor experience.
2. Seeing a mountain lion would help me enjoy an outdoor experience.
3. I enjoy knowing mountain lions live in Texas.
4. Mountain lions are an essential part of nature.
5. The potential presence of mountain lions causes many people to avoid outdoor activities.
Statements from which we derived general attitude about mountain lion management and research:
1. Mountain lions should be protected.
2. Mountain lions should not be protected under any circumstances.
3. Valuable information could be obtained from scientific studies of mountain lion populations.
4. Efforts should be made to ensure the survival of mountains lions in Texas.
Statements from which we assessed trust in state wildlife management of mountain lions:
1. I trust the state to manage mountain lions.
2. State officials are concerned about minimising the threats of mountain lions to residents.
3. The state does a competent job of minimising the threats of mountain lions.
4. The state is open and honest in the things they do and say when managing mountain lions.
5. The state makes decisions about managing mountain lions in a way that is fair.
6. The state listens to our concerns when managing mountain lions.
7. The state draws upon sound science to make decisions about mountain lion management.

animals to mountain lions. All responses were recorded on a 5-point Likert scale (range from -2 or strongly disagree, to + 2 or strongly agree).

We also assessed ratios of the percentage of people who strongly supported versus strongly opposed (+2 and -2 on a 5-point Likert scale) trapping-based management, hunting-based management, compensation programmes for livestock losses and mountain lion conservation management more broadly. People with the strongest opinions are those most likely to act on their beliefs (Krosnick and Petty 1995), including actions such as attending and speaking at public meetings, calling a wildlife official or politician or arguing for a particular viewpoint on social media or in newspapers.

Data analysis

Overall, recruited participants represented male to female ratios reported in the 2020 Census for Texas, but did not represent proportional relationships of ethnicity (i.e. 61% white, 39% Hispanic in the 2020 Census, versus 19% Hispanic in the survey). Therefore, we used the 'SURVEY' package (Lumley 2021) in R (ver. 3.6.2) to weight the data to match these proportions.

For each of the questions below, we analysed all respondents pooled together as our best representation of the attitudes, beliefs and values of the general public in Texas. Next, we performed the analyses separating four comparative stakeholder ingroups to evaluate any differences in their responses: 1) hunters vs. non-hunters; 2) livestock owners vs. people without livestock; 3) rural vs. suburban/urban respondents; and 4) Hispanics vs. non-Hispanics. Given that 39% of Texans are Hispanic or Latino (United States Census Bureau 2020), potential differences in

this stakeholder group's responses were of interest to avoid the historic marginalisation of this constituency and to ensure their equitable representation in any forthcoming mountain lion management decisions (Chase et al. 2016).

We used parametric tests in R version 3.6.2 for Mac OS X to relate participant responses (perceptions and Likert scale) with independent variables (e.g. comparative groups – hunters, livestock producers, urban vs. rural, ethnicity), as our sample sizes (> 30) were large enough to assume the distribution of sample means will likely approach a normal distribution (i.e. Central Limit Theorem) (Newing et al. 2011). T-tests were used when comparing means (from sums of attitude statements combined into additive scores) (Zimmermann et al. 2005) of two independent groups (e.g. trust in agency between hunters and non-hunters) and significance was determined at the $p = 0.05$ threshold; no correction tests were needed in this case (García-Pérez 2023). We used chi-square tests with a Rao and Scott adjustment (Rao and Scott 1987), here reported as an F statistic, to determine whether there were proportional differences in selecting specific responses amongst ingroups (e.g. legal status of mountain lions and the four comparative groups). When differences were detected, we employed z-proportions tests to determine which response category differed amongst comparative groups.

Results

Participants

Qualtrics secured 740 respondents, but we were unable to meet the objective quotas (e.g. equal urban-rural representation and a sample reflective of the sociodemographic profile of Texas) set by the researchers responsible for the survey. Of the 740 respondents, 237 people reported living in rural zip codes (Fig. 1), 89 reported having participated in hunting or trapping in the previous 12 months, 87 reported owning or raising livestock in the previous 12 months and 141 self-identified as Hispanic. After weighting the data to account for an under-representation of Hispanic people amongst respondents, our analytical sample size for statistical tests was reduced to 702 people. In terms of sex, 505 respondents were female, 223 male, five non-binary, four stated they preferred not to answer and one did not answer the question.

Knowledge of the Current Status of Mountain Lions in Texas

More respondents correctly reported that mountain lions were rare, but not endangered (32%) than any other response and 28% believed mountain lions were endangered. Twenty-one percent reported that they did not know the status of mountain lions, 13% reported that they were common and 5% indicated that they were extinct. There were differences in the proportional responses for hunters versus non-hunters ($F_{3.89,\ 2725.0} = 2.830$, $p = 0.025$). More hunters reported that mountain lions were common than non-hunters, which is inconsistent with current scientific knowledge (Elbroch and Harveson 2022) and more non-hunters reported that they did not know the current status of mountain lions in Texas (Table 2).

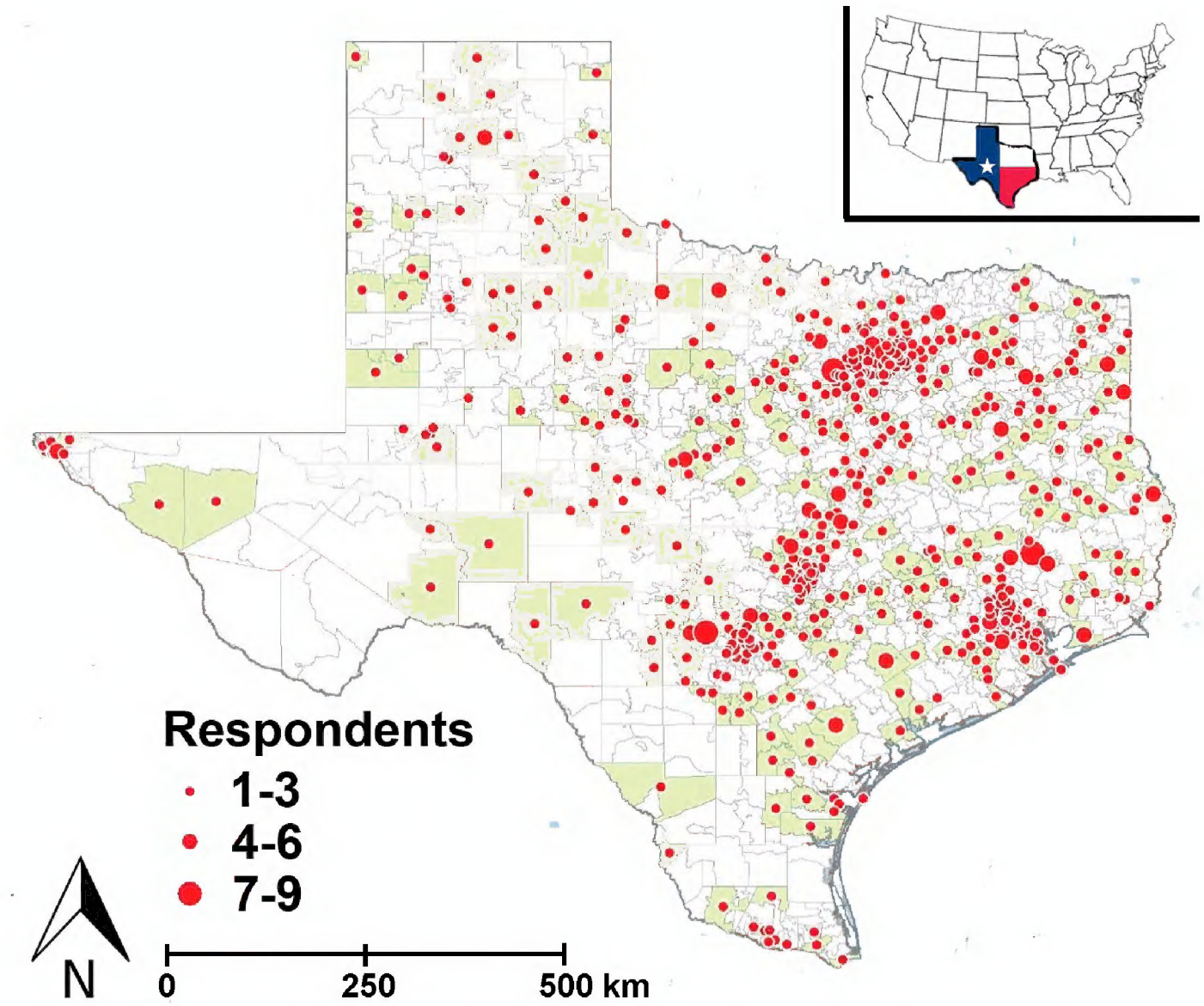

Figure 1. Inset shows the location of Texas in the contiguous United States. Main map displays the geographical distribution of survey respondents within Texas (Ghasemi et al. 2022). Green counties were those in which participants resided.

Livestock owners also reported that mountain lions were common more often than people without livestock (though inconsistent with state of knowledge about the species in Texas; Elbroch and Harveson (2022)) and more livestock owners misreported that mountain lions were extinct (Table 2). Similar to non-hunters, more people who did not own livestock reported that they did not know the current status of mountain lions in Texas (Table 2). Neither place of residence (urban vs. rural) ($F_{4.0,\ 2799.2} = 0.577$, $p = 0.679$) nor ethnicity ($F_{4.0,\ 2801.1} = 1.527$, $p = 0.192$) influenced responses about the status of mountain lions in Texas.

Overall, the majority of respondents (45%) believed mountain lions are a protected species that cannot be hunted or trapped, which is not true in Texas. There were, however, differences in the proportional responses for hunters versus non-hunters ($F_{3.00,\ 2100.7} = 5.496$, $p = 0.001$). For example, hunters were more likely to report that mountain lions were a “game” species in Texas with some protections than non-hunters (Table 2). However, hunters were also more likely to correctly report that mountain lions were a non-game species with unmanaged harvest or reporting. In contrast, a larger proportion of non-hunters believed that mountain lions are a protected species, which is not true in Texas (Table 2). Place of residence (urban vs. rural) ($F_{3.0,\ 2100.2} = 0.125$, $p = 0.945$), ethnicity ($F_{3.0,\ 2101.7} = 1.666$, $p = 0.172$) and livestock ownership ($F_{2.99,\ 2093.8} = 2.143$, $p = 0.093$) did not influence responses about current mountain lion management in Texas.

Table 2. Proportional responses (%) of comparative stakeholder ingroups with regards to the current population and management status of mountain lions in Texas.

		Hunter	**Non-hunter**	***z***	***p***
Current population status of mountain lions	Common	23.3	11.7	2.826	0.004
	Endangered	21.2	29.1	-1.434	0.153
	Extinct	5.7	5.4	0.097	0.920
	I don't know	11.0	22.6	-2.312	0.021
	Rare	38.8	31.1	1.339	0.180
		Livestock	**No livestock**	***z***	***p***
	Common	19.8	12.0	1.979	0.048
	Endangered	21.2	29.2	-1.504	0.134
	Extinct	12.8	4.5	3.075	0.002
	I don't know	8.9	23.0	-2.905	0.004
	Rare	37.2	31.2	1.085	0.276
		Hunter	**Non-hunter**	***z***	***p***
	Game	17.8	8.8	2.440	0.015
Current management of mountain lions	I don't know	20.9	26.2	-0.981	0.327
	Non-game	31.9	17.2	3.050	0.002
	Protected	29.4	47.7	-2.983	0.003

General Attitudes about Mountain Lions

Respondents exhibited a slightly more positive than neutral attitude about mountain lions (mean score = 0.38 ± 0.08 SE). Hunters and livestock owners expressed more positive attitudes about mountain lions than non-hunters and people who do not own livestock (Table 3). There was no difference in attitudes between rural versus urban respondents (t_{700} = 0.942, p = 0.347) or Hispanic versus non-Hispanic respondents (t_{700} = 0.138, p = 0.889).

For every 35 respondents who strongly agreed with the statement describing mountain lions as an essential part of nature, only four people strongly disagreed. In contrast, for every 12 respondents who strongly agreed with the statement that it is exciting to find footprints of mountain lions in the field, 17 strongly disagreed (Table 4). This pattern was also clear in terms of general consensus amongst participants. Respondents exhibited the highest consensus in their belief that mountain lions are an essential part of nature (PCI_2 = 0.16) and the least consensus (i.e. the greatest potential for conflict) regarding statements about the influence of seeing the footprint of a mountain lion (PCI_2 = 0.31) or the actual animal (PCI_2 = 0.33) on one's outdoor experience (Fig. 2).

Attitudes about Mountain Lion Management

Respondents expressed slightly positive support for managing mountain lions (mean score = 1.04 ± 0.06 SE). There were no differences in responses amongst hunters and non-hunters, although the results were marginal (Table 3). We did not find differences between livestock owners and people without livestock, rural versus urban inhabitants or Hispanic versus non-Hispanic respondents (Table 3).

Table 3. Mean attitude ± standard error (SE), as determined by scoring responses on relevant questions on a -2 to +2 scale, amongst respondent subgroups about mountain lions, mountain lion management and their trust in the Texas state wildlife agency, followed by results of t tests to determine whether paired groups differed from one another.

		Mean ± SE		Mean ± SE	t_{700}	*p*
Attitude about mountain lions	Hunter	0.98 ± 0.30	Non-hunter	0.31 ± 0.08	-2.116	0.03
	Livestock	0.93 ± 0.28	No livestock	0.31 ± 0.08	-2.104	0.04
	Urban	0.49 ± 0.15	Rural	0.32 ± 0.09	0.942	0.347
	Hispanic	0.37 ± 0.16	Non-hispanic	0.39 ± 0.08	0.138	0.889
Attitude about mountain lion management	Hunter	0.69 ± 0.19	Non-hunter	1.08 ± 0.06	1.881	0.06
	Livestock	1.02 ± 0.19	No livestock	1.04 ± 0.07	0.118	0.905
	Urban	1.00 ± 0.11	Rural	1.06 ± 0.07	-0.466	0.641
	Hispanic	0.97 ± 0.12	Non-hispanic	1.09 ± 0.07	0.834	0.404
Trust in the state wildlife agency	Hunter	3.47 ± 0.62	Non-hunter	2.08 ± 0.24	-2.082	0.03
	Livestock	3.46 ± 0.63	No livestock	2.07 ± 0.24	-2.075	0.03
	Urban	1.99 ± 0.41	Rural	2.37 ± 0.27	-0.746	0.455
	Hispanic	1.68 ± 0.47	Non-hispanic	2.58 ± 0.22	1.736	0.08

Overall, there was a much larger proportion of participants who "strongly agreed" with statements expressing positive support for mountain lion management than there were those who "strongly disagree" with mountain lion management (Table 4). For example, for every 32 people who strongly agreed with the statement that mountain lions should be protected, five people strongly disagreed with the statement. Similarly, for every 31 people who strongly agreed with the statement that efforts should be made to ensure mountain lion survival in Texas, five people strongly disagreed with this assertion (Table 4).

Texans exhibited the highest consensus (PCI_2 = 0.11) in their belief that science and research are important. Texas respondents demonstrated the least consensus around the statement that mountain lions should not be protected under any circumstance (PCI_2 = 0.23) (Fig. 2).

Assessing trust in the Texas Parks and Wildlife Department to effectively manage mountain lions

In general, Texans exhibited modest trust in TPWD in relation to managing mountain lions and employing the best available science to guide decisions about mountain lion management (mean score = 2.23 ± 0.23 SE). However, hunters and livestock owners expressed greater positive attitudes about TPWD than did non-hunters and people without livestock (Table 3). There were no significant differences in trust at the $p < 0.05$ threshold amongst rural versus urban inhabitants nor amongst Hispanics versus non-Hispanics (Table 3).

Overall, Texas residents demonstrated medium to high consensus in their trust towards TPWD (Fig. 2). In particular, there was high consensus for the statement that TPWD makes scientifically sound decisions about managing mountain lions (PCI_2 = 0.09). Conversely, there was less consensus (PCI_2 = 0.15) and a more neutral view about the statement about how honest and transparent TPWD is in their management of mountain lions (Fig. 2).

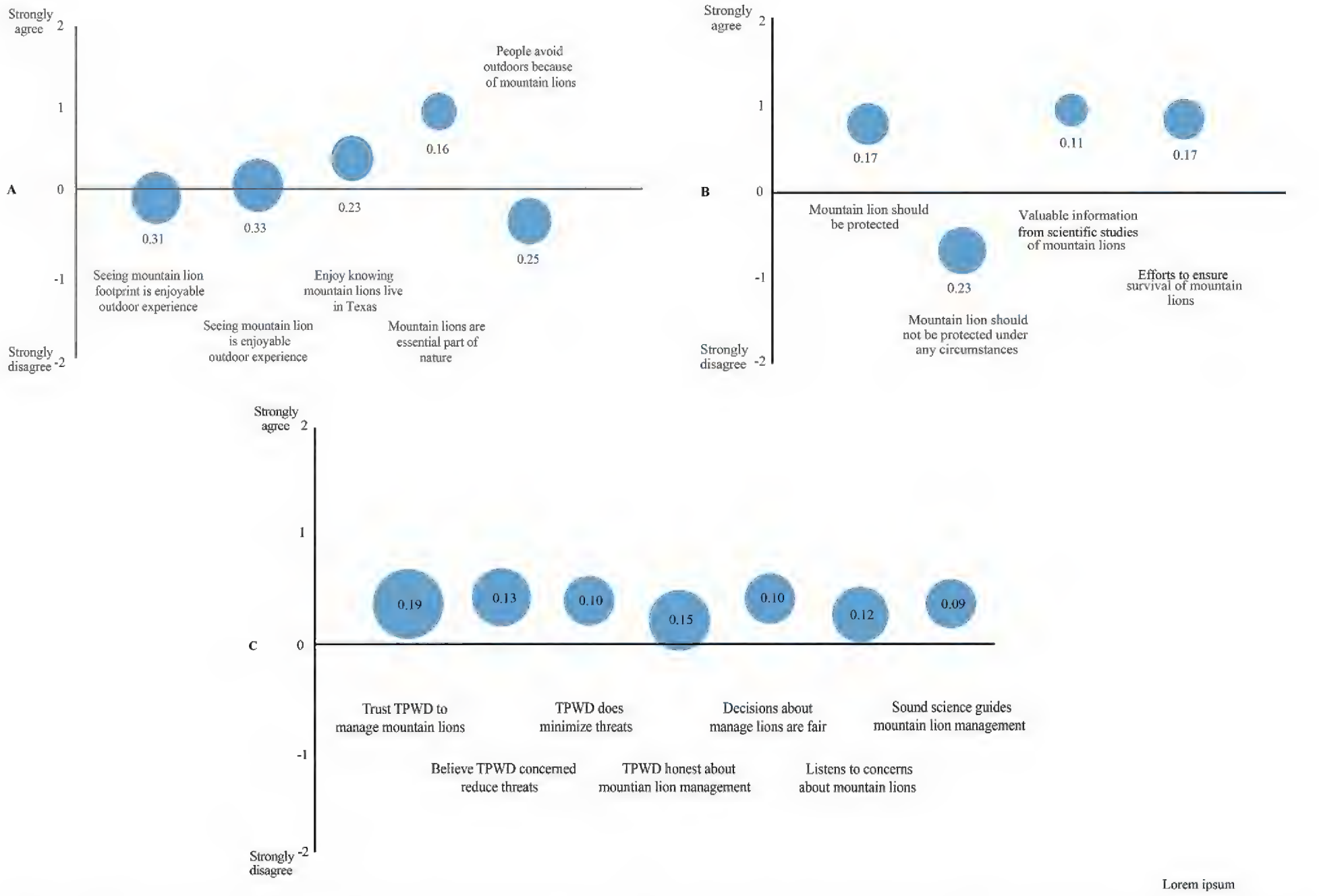

Figure 2. Mean scores for statements reflecting general attitude about: **A.** Mountain lions; **B.** Mountain lion management; **C.** The trustworthiness of TPWD and their related PCI_2 scores. The larger the PCI_2 value and the size of the circle, the less consensus amongst respondents and the greater potential for conflict.

Trapping Regulations and Mandatory Harvest Reporting

The people of Texas overwhelmingly supported daily trap checks for mountain lions. When indicating their preferred rate of trap checks, 64% of respondents selected daily trap checks, 11% selected every 36 hours (the current trapping regulation for fur-bearers in Texas), 6% selected every 48 hours, 1% selected every 72 hours, 6% were unsure, 1% expressed that there should not be trap checks and 7% expressed that trapping should not be allowed. There were no significant differences in the proportional selection in the eight answer categories amongst hunters versus non-hunters ($F_{6.3,\ 4399.6} = 1.169$, $p = 0.319$), livestock owners vs. people without livestock ($F_{6.6,\ 4638.0} = 0.672$, $p = 0.687$), rural versus urban inhabitants ($F_{6.9,\ 4856.5} = 0.848$, $p = 0.546$) or Hispanics versus non-Hispanics ($F_{6.9,\ 4869.0} = 0.974$, $p = 0.448$).

Texas residents strongly approved of the reporting of any mountain lions killed or euthanised in the State. Seventy-four percent of respondents supported harvest reporting, 18% were unsure and 8% did not support harvest reporting. There were differences in the proportional responses for hunters versus non-hunters ($F_{1.89,\ 1327.0} = 5.423$, $p = 0.005$). Equal numbers of hunters and non-hunters supported mandatory reporting (77% vs. 74%, $z = 0.648$, $p = 0.516$), but more hunters opposed it than non-hunters (15% vs. 7%, $z = 2.597$, $p = 0.009$) and more

non-hunters were unsure than hunters (7% vs. 19%, z = -2.534, p = 0.011). We found no significant differences in proportional selection in the three answer categories amongst livestock owners versus people without livestock ($F_{2.0, 1396.6}$ = 0.443, p = 0.641), rural versus urban inhabitants ($F_{2.0, 1401.3}$ = 0.251, p = 0.778) or Hispanics versus non-Hispanics ($F_{2.0, 1401.9}$ = 0.936, p = 0.393).

Other Management Considerations

Respondents were neutral (mean score = 0.057 ± 0.09 SE) with regard to the use of trapping as a management tool for mountain lions in Texas. There were no differences of opinion amongst any stakeholder ingroup that was tested. For every seven people who were strongly opposed to trapping as a management tool, there were six people who indicated strong support for this type of management (Table 4).

In comparison, Texas residents (mean score = -0.103 ± 0.09 SE) were just slightly negative of neutral with regard to the use of hunting as a management tool for mountain lions. Hunters (mean score = 0.83 ± 0.20 SE) expressed support for hunting as a management tool, whereas non-hunters (mean score = -0.22 ± 0.09) (t_{231} = -4.843, p < 0.001) were slightly against hunting as a management option. Livestock producers (mean score = 0.30 ± 0.21 SE) similarly

Table 4. Proportional responses (%) to five statements amongst respondents reflecting general attitude about mountain lions, five statements reflecting general attitude about mountain lion managemen, and three statements about potential mountain lion management tools.

	Strongly disagree	Somewhat disagree	Neutral	Somewhat agree	Strongly Agree
General attitude about mountain lions					
Seeing track of mountain lion would help enjoy outdoor experience.	17	16	30	25	12
Seeing a mountain lion would help enjoy outdoor experience.	17	13	28	27	16
Enjoy knowing mountain lions live in Texas.	10	8	34	26	23
Mountain lions are essential part of nature.	4	4	15	41	35
*Potential presence of mountain lions causes people to avoid outdoor activities.	8	15	29	33	15
General attitude about mountain lion management					
Mountain lions should be protected.	5	5	28	30	32
*Mountain lions should not be protected under any circumstances.	34	22	28	10	5
Valuable information could be obtained from scientific studies of mountain lion populations.	3	3	20	44	29
Efforts should be made to ensure the survival of mountains lions in Texas.	5	5	24	35	31
General attitude about potential mountain lion management tools					
Trapping is an acceptable way of managing mountain lion populations.	14	12	36	25	12
Hunting is an acceptable way of managing mountain lion populations.	18	18	32	21	11
I would endorse a state management plan that compensates livestock producers for livestock loss from mountain lion predation.	5	6	35	34	20

(*) indicates statements for which we inversed values.

expressed a slightly positive view of hunting as a management tool, whereas people without livestock (mean score = -0.16 ± 0.09 SE) (t_{231} = -1.978, p = 0.049) were slightly opposed to management via hunting. There were no significant differences of opinion between rural versus urban residents (t_{231} = 0.752, p = 0.452) or Hispanics and non-Hispanics (t_{231} = -0.566, p = 0.572).

Texans expressed support for a compensation programme to aid livestock owners who lose animals to mountain lions (mean score = 0.570 ± 0.07 SE). For every person who strongly opposed such a programme, four expressed strong support for livestock compensation initiatives (Table 4). There were no significant differences amongst responses made by our four ingroups of interest (hunter versus non-hunter, t = -1.489, p = 0.138; livestock versus no livestock, t = -0.756 p = 0.450; rural versus urban, t = -0.450, p = 0.653; and non-Hispanic versus Hispanic, t = 0.076, p = 0.94).

Discussion

Overall, survey respondents expressed positive, albeit modest, attitudes about mountain lions and state management of the species. Respondents demonstrated consensus in their valuation of scientific research about mountain lions and the need for science to guide management decisions by TPWD. They also expressed support for mandatory reporting of any mountain lion killed for any purpose by hunters, trappers or state or federal agents and for daily checks of traps set in the field. Fifty-four percent of respondents somewhat or strongly support the implementation of a livestock compensation programme for producers who lose animals to mountain lions.

Assuming these survey data captured attitudes that reflect values and potential behaviour, our analyses suggest that the people of Texas, inclusive of hunters and livestock producers, support the first three proposed activities in the 2022 Petition for Rulemaking received by the TPWD: 1) Conduct a state-wide study to identify the abundance, status and distribution of the mountain lion populations in Texas; 2) Require mandatory reporting of wild mountain lions killed or euthanised for any reason by members of the public, state and federal agents acting in their official capacity and other wildlife responders; 3) Require trappers employing any form of trap or snare to capture mountain lions to examine their devices at least once every 36 hours, to make mountain lion trapping consistent with current fur-bearer trapping regulations in Texas. This survey did not directly assess the attitudes of Texans in relation to either activities Four or Five of the 2022 Petition. We would also caution readers that attitudes do not always directly translate into behaviour (Heberlein 2012), as decision-making has been shown to include a complex interplay of individual and contextual factors, such as social norms, control beliefs and external conditions (i.e. Theory of Planned Behaviour, Ajzen (1991)).

Hunters versus non-hunters and livestock producers versus people without livestock exhibited some differences in support for and attitudes about mountain lions and mountain lion management. However, these discrepancies were not entirely in alignment with our initial predictions, based on the existing literature (Davenport et al. 2010; Vantassel et al. 2010; White et al. 2021). Our survey revealed that hunters and livestock producers in Texas expressed more positive attitudes for mountain lions and their management than did non-hunters and people who do not own livestock. This finding aligns with the report by Engel et al. (2017) that those

with greater knowledge of pumas expressed less fear about them and were overall more tolerant of them in the Atlantic Forest of Brazil. The positive attitudes exhibited by hunters and livestock owners are noteworthy, considering that state agencies often believe they are acting on behalf of their constituents when they reduce large carnivore populations or implement more liberal harvest management of these species (e.g. Treves et al. (2015); Mitchell et al. (2018); Proffitt et al. (2020)).

Hunters and livestock owners also expressed higher levels of trust in state wildlife management than did non-hunters and Texans who did not own livestock. We predicted this trend given that these stakeholders are generally more engaged with state wildlife agencies and predominantly viewed as the primary constituents of state wildlife programmes (Adams et al. 1997; Decker et al. 2019). Trust in the institutions responsible for wildlife management has been proposed as a key predictor for positive attitudes towards the wildlife that these agencies manage as well as an antecedent for the tolerance of wildlife, including large terrestrial carnivores like mountain lions (e.g. Bruskotter and Wilson (2014); Kansky et al. (2016)). Evidence for this influence of social trust in wildlife managers on predator acceptance has been provided by several case studies of large mammalian carnivores: wolves in Italy (Marino et al. 2016) and black bears in Colorado (Wilbur et al. 2018). Satisfaction with wildlife management authorities was the third strongest predictor of Colorado citizens' reports of "nuisance" bear complaints to the state institutions responsible for bear management (Wilbur et al. 2018). Similarly, Italian sheep herders' distrust in local and provincial governmental institutions was significantly related to retaliatory killings of protected wolves (Marino et al. 2016). The correlation between greater trust in TPWD and more positive attitudes towards mountain lions and their management amongst our survey participants provides additional support for the relationship between trust in wildlife management agencies and individuals' positive attitudes towards wildlife and their management.

We did not detect differences in the responses between rural and urban respondents, dispelling the assumption that there are clear attitudinal divisions between people living sympatric with large carnivores in rural areas and those living more isolated from large carnivores in urban or suburban environments (Williams et al. 2002; Karlsson and Sjöström 2007). This again is a result with far-reaching implications, given current assumptions that rural people are less supportive of conserving carnivores because they bear the costs associated with these species (Young et al. 2015; Knopff et al. 2016). For example, Human Dimensions research to date indicates that rural people are less supportive of wolf conservation (Karlsson & Sjöström 2007) and that hunters are less supportive of seeing carnivore restoration than non-hunters (New York; McGovern and Kretser (2015), northern Wisconsin; Olson et al. (2021)). The idea that hunters and non-hunters, as well as urban and rural people, are at odds is a frequent theme in both mainstream and peer-reviewed conservation literature. Our work, however, suggests that there is common ground upon which to build shared, integrated and adaptive conservation strategies for large carnivores.

There were also no differences between the overall responses of Hispanic and non-Hispanic participants and we did not find strong opposition to trapping-based management amongst Texans in general. The latter result was likely due to the broad framing of the question, which enabled "trapping management" to include diverse trapping activities, ranging from controlling invasive species to protect local resources to recreational trapping for fur sales to

international markets. In contrast, survey respondents exhibited slightly negative attitudes about hunting-based management, an unexpected result considering that our participant pool included a high representation of hunters (12% of participants in this survey were hunters in comparison to previous reports that state only 4% of Texans hunt; Stacker (2021)).

Respondents expressed positive attitudes for mountain lions, the management of this species in Texas and their trust of TPWD, though their responses were only slightly better than neutral. In part, these attitudes may be attributable to the perceived or real risks of co-existing with mountain lions (e.g. the proportional negative versus positive responses about finding mountain lion tracks in the field or seeing the actual animal in Table 3) (Riley and Decker 2000; Johansson and Karlsson 2011; Bruskotter and Wilson 2014; Olson et al. 2021). With regards to mountain lions, research suggests that those who perceive greater risks associated with the species tend to be less supportive of seeing their restoration into former ranges from which they were extirpated or even maintaining existing populations where they currently exist (McGovern and Kretser 2015 Olson et al. 2021). The modest positive attitude for mountain lions may further be indicative of a general disengagement with the state wildlife agency, wildlife topics in general or perhaps in relation to mountain lions specifically. For example, the majority of respondents misclassified the current management and population status of mountain lions in Texas. Most respondents also thought that mountain lions were a protected species in Texas. These results highlight the need for TPWD to prioritise public outreach and education for a greater diversity of Texans to: 1) mitigate the perceptions of risks and/or costs associated with mountain lions, especially since the perceived risks associated with mountain lions are generally greater than the actual risks (Riley and Decker 2000; Olson et al. 2021); 2) increase public knowledge about mountain lions and their management and 3) simultaneously foster greater trust in natural resource governance in order to promote tolerance of mountain lions (*sensu* Bruskotter and Wilson (2014)) and to prevent disengagement by the public (Rapp 2020).

This survey did hold limitations. Although efforts were made to ensure broad representation, certain populations remained under-represented, including rural and Hispanic populations and the online delivery of the survey may have also biased results or access and understanding. The survey designers also tried to reduce respondent fatigue by presenting different components of the survey to different respondents and we do not know whether this impacted composite scores, especially given that some positive statements lacked negative counterparts that may have introduced acquiescence bias. Although a few corrections were applied to some comparison tests, not all were corrected, which may have influenced the results. Furthermore, subgroup analyses may have been biased by overlapping characteristics, impacting the generalisability. We suggest that further research should focus on adopting more inclusive sampling strategies and validating measurement tools across diverse cultural contexts.

Conclusions

Our survey findings provide a strong basis from which the Texas mountain lion stakeholder working group, the Texas Wildlife Commission, TPWD and other interested and affected parties can plan, implement, continuously assess and

adapt any mountain lion management policies and practices. More broadly, our results suggest that the common assumptions of hunters and rural residents being more negative about large carnivores may not be justified. In the very least, attitudes amongst these groups are clearly more complex than previous analyses suggest. In our work, hunters and livestock owners were more positive about mountain lions, augmenting previous Human Dimensions studies that linked knowledge of wildlife and/or trust in wildlife management agencies to positive attitudes towards wildlife and their management. Ultimately, our results provide Texas wildlife managers the opportunity to better integrate equitable representation of the diverse perspectives of all Texas constituents when creating a defensible, adaptive and integrated management plan to preserve mountain lion populations, Texas communities and the ecosystems on which we all depend.

Additional information

Conflict of interest

LME is one of the authors of the 2022 Petition for Rulemaking to TPWD that proposed new mountain lion policies.

Ethical statement

No ethical statement was reported.

Use of AI

No use of AI was reported.

Funding

No funding was reported.

Author contributions

Conceptualization: LME. Data curation: OO. Formal analysis: LME, OO. Writing - original draft: LME. Writing - review and editing: BEGW, BG, OO, LME.

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Data availability

All data used in this manuscript are available upon request to the corresponding author.

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